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(56) Documents Cited:
GB 2389764 A **US 6673281 B1**

(58) Field of Search:
INT CL[7] **G06F, G06T**
Other: **ONLINE: EPODOC, WPI, INTERNET**

(54) Abstract Title: **Wrapping complex textures onto 3D CAD models**

(57) Complex 3D low relief models, represented as triangular mesh stored as industry standard (STL) or proprietary format are wrapped directly onto computer aided design (CAD) models of 3D objects for manufacturing a prototype or mould or die cavity or core. The mesh representation of the relief is positioned over the target surface and its nodes projected onto it using chord length, planar, cylindrical, conical or isoparametric lines. The nodes are offset to set a relief height. Trim curves are formed where they meet the target surface. As a feature of the underlying target model the relief is rewrapped automatically when the target is modified. The target surface may be unwrapped as a template for creating the initial relief texture. Relief and target model geometry is stored in the same database. The method provides a rapid method for creating complex decoration on things like bottles and containers avoiding manual processes like etching and engraving.

FIGURE 2

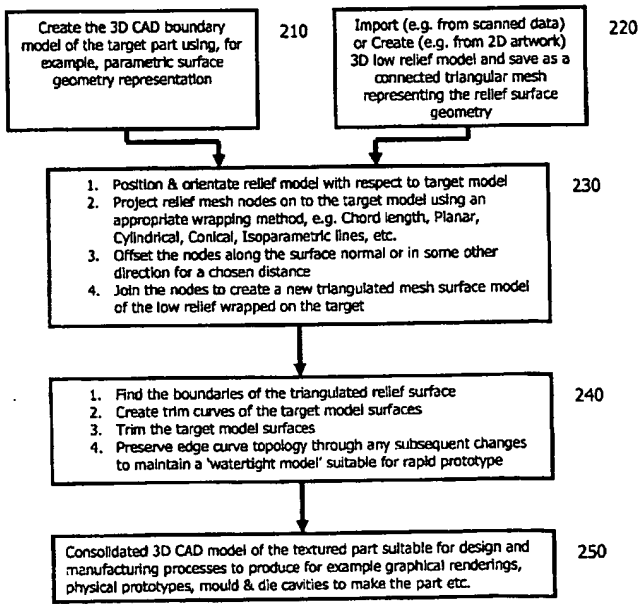

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FIGURE 1

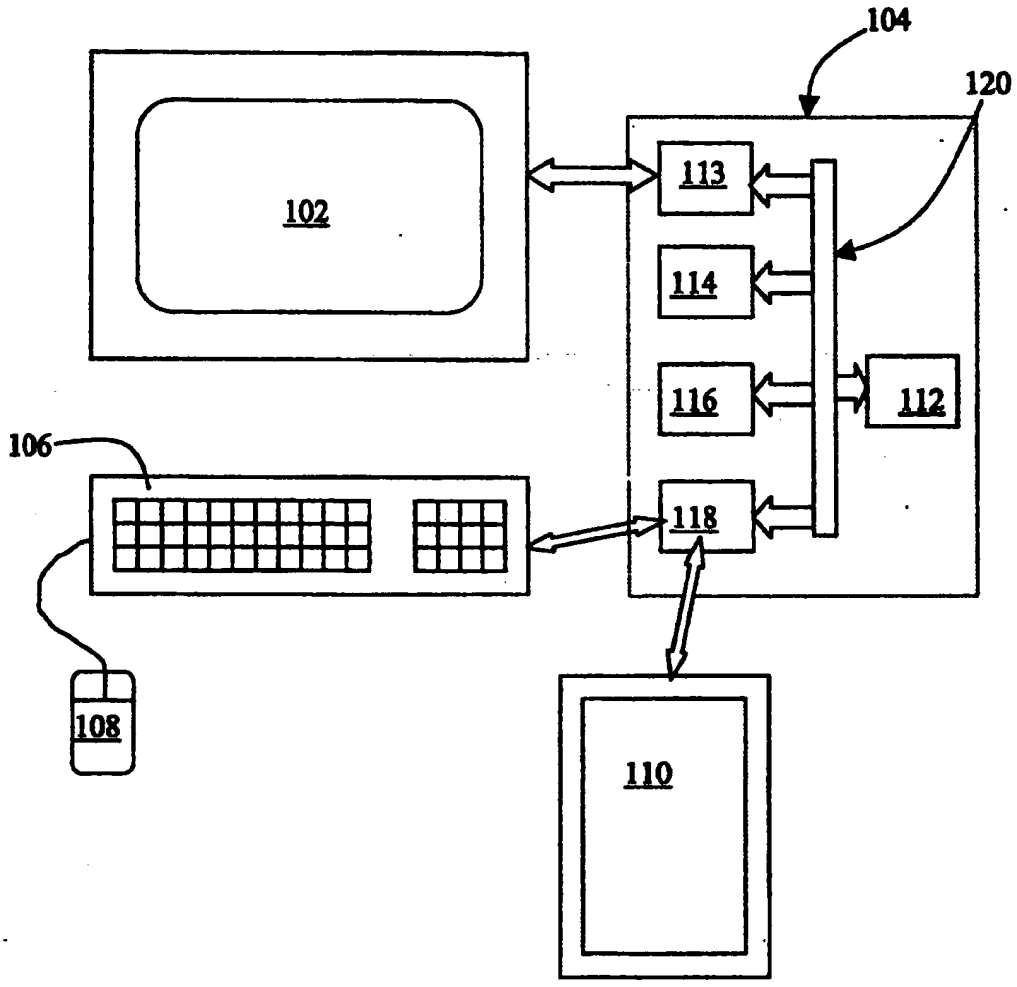


FIGURE 2

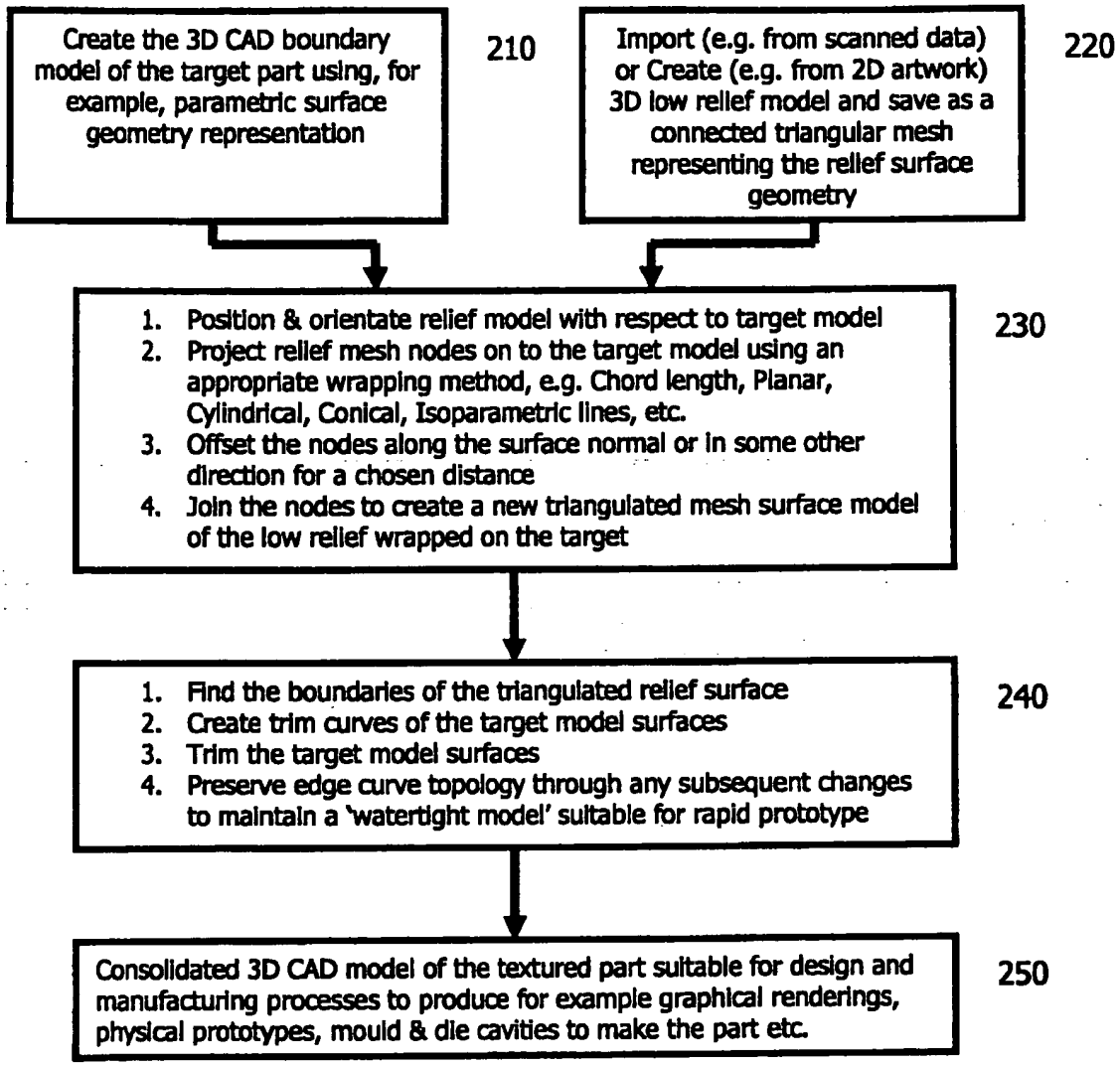

Create the 3D CAD boundary model of the target part using, for example, parametric surface geometry representation
210
Import (e.g. from scanned data) or Create (e.g. from 2D artwork) 3D low relief model and save as a connected triangular mesh representing the relief surface geometry
220
1. Position & orientate relief model with respect to target model
2. Project relief mesh nodes on to the target model using an appropriate wrapping method, e.g. Chord length, Planar, Cylindrical, Conical, Isoparametric lines, etc.
3. Offset the nodes along the surface normal or in some other direction for a chosen distance
4. Join the nodes to create a new triangulated mesh surface model of the low relief wrapped on the target
230
1. Find the boundaries of the triangulated relief surface
2. Create trim curves of the target model surfaces
3. Trim the target model surfaces
4. Preserve edge curve topology through any subsequent changes to maintain a 'watertight model' suitable for rapid prototype
240
Consolidated 3D CAD model of the textured part suitable for design and manufacturing processes to produce for example graphical renderings, physical prototypes, mould & die cavities to make the part etc.
250

Figure 3

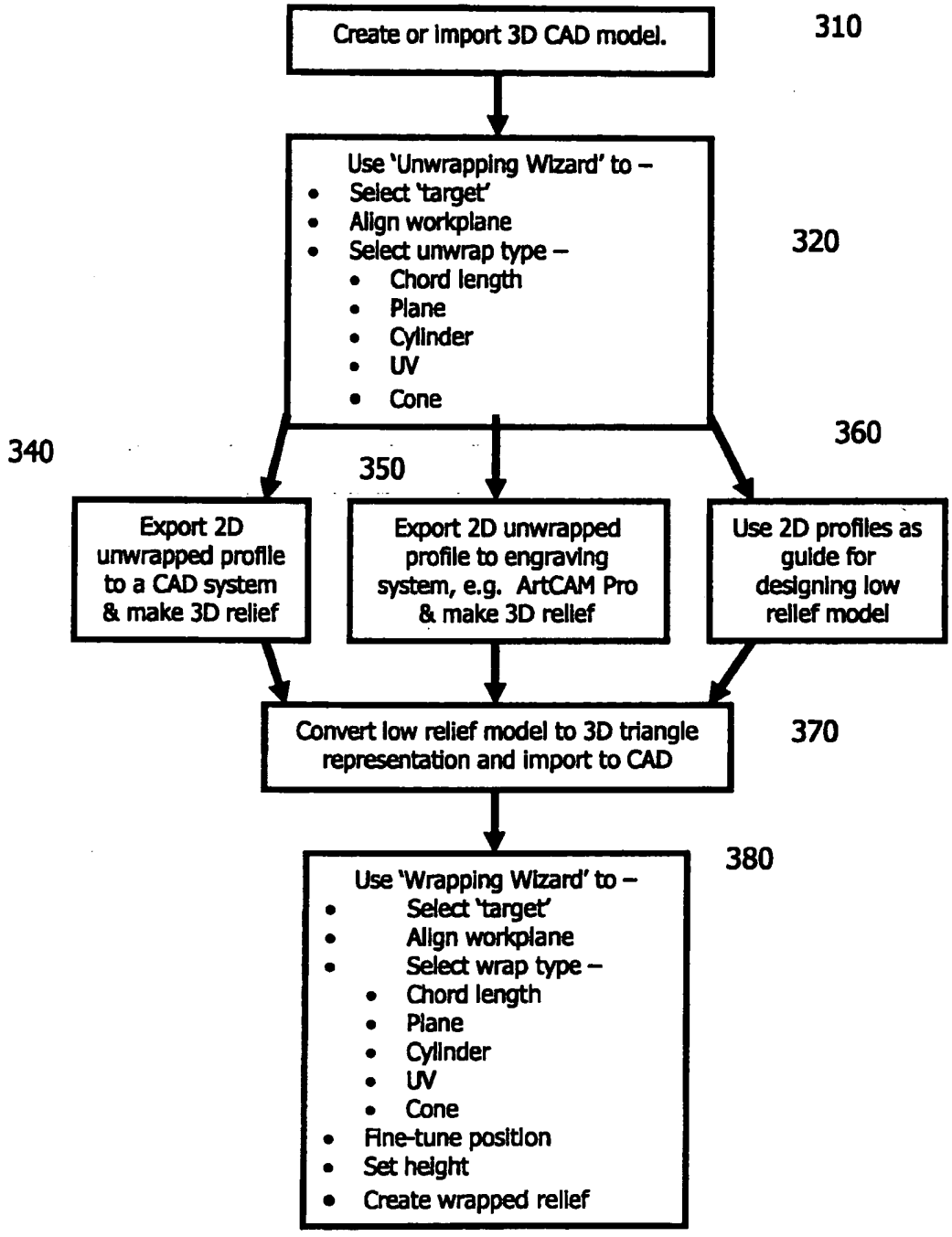

Create or import 3D CAD model.
310
Use 'Unwrapping Wizard' to –
Select 'target'
Align workplane
Select unwrap type –
Chord length
Plane
Cylinder
UV
Cone
320
340
350
360
Export 2D unwrapped profile to a CAD system & make 3D relief
Export 2D unwrapped profile to engraving system, e.g. ArtCAM Pro & make 3D relief
Use 2D profiles as guide for designing low relief model
Convert low relief model to 3D triangle representation and import to CAD
370
380
Use 'Wrapping Wizard' to –
Select 'target'
Align workplane
Select wrap type –
Chord length
Plane
Cylinder
UV
Cone
Fine-tune position
Set height
Create wrapped relief

Figure 4

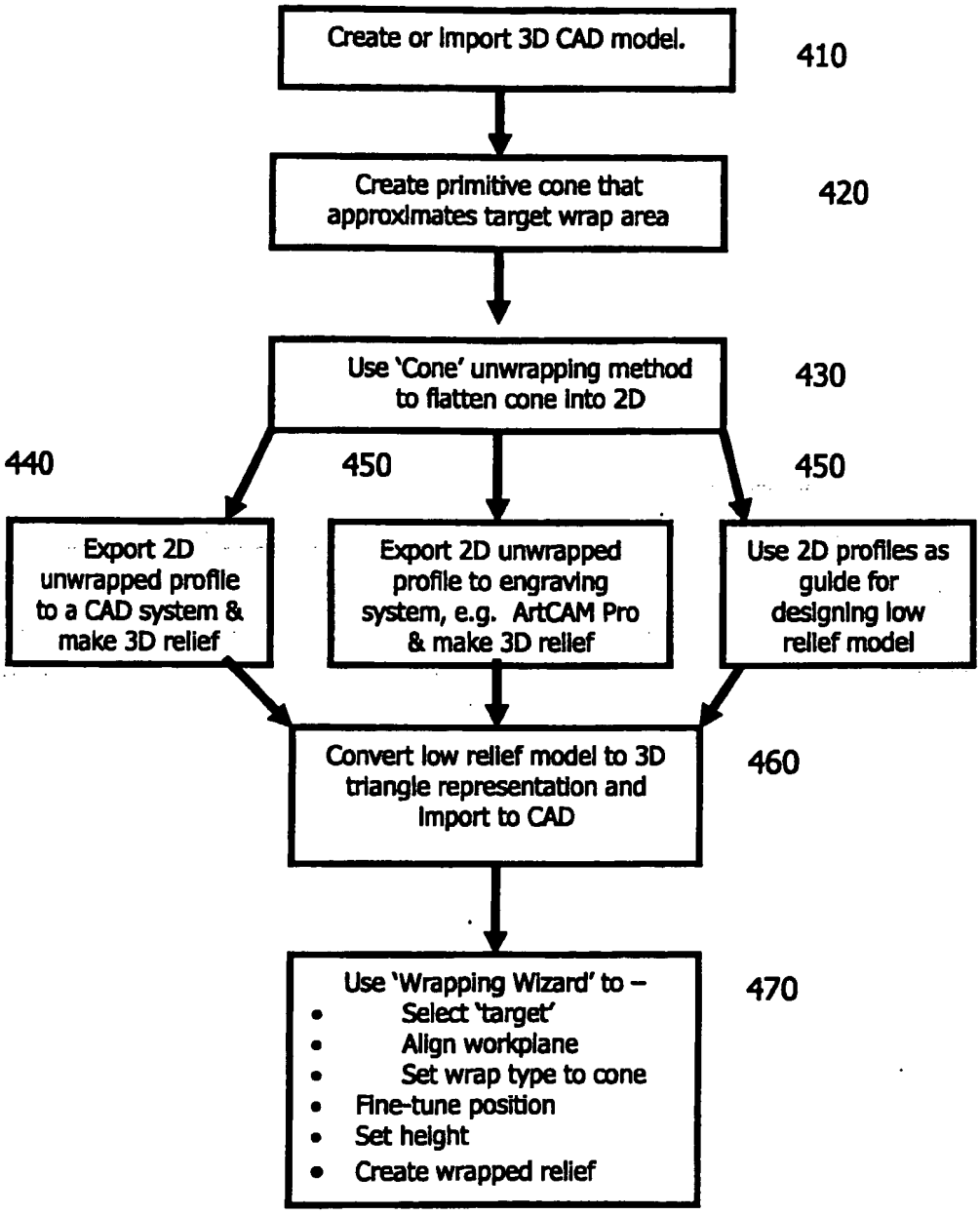

Create or import 3D CAD model.
410
Create primitive cone that approximates target wrap area
420
Use 'Cone' unwrapping method to flatten cone into 2D
430
440
450
450
Export 2D unwrapped profile to a CAD system & make 3D relief
Export 2D unwrapped profile to engraving system, e.g. ArtCAM Pro & make 3D relief
Use 2D profiles as guide for designing low relief model
Convert low relief model to 3D triangle representation and import to CAD
460
Use 'Wrapping Wizard' to –
• Select 'target'
• Align workplane
• Set wrap type to cone
• Fine-tune position
• Set height
• Create wrapped relief
470

Figure 5

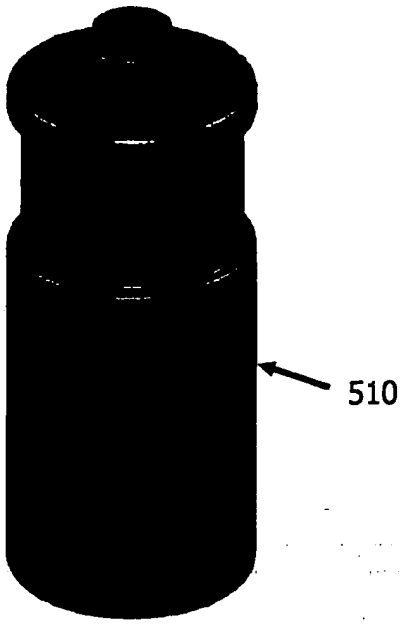


Figure 6

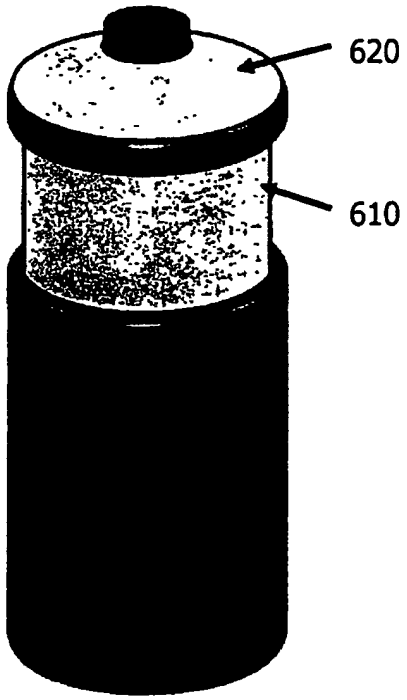


Figure 7

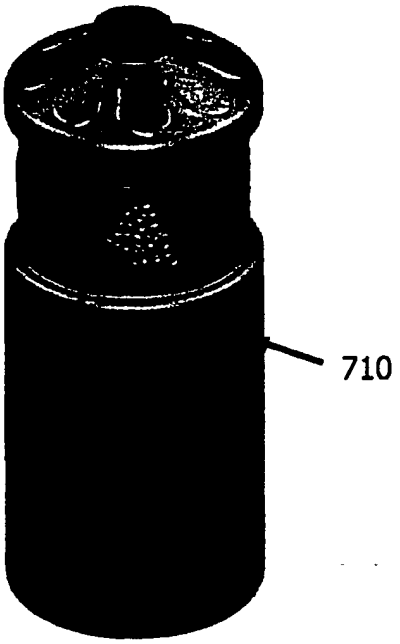


Figure 8

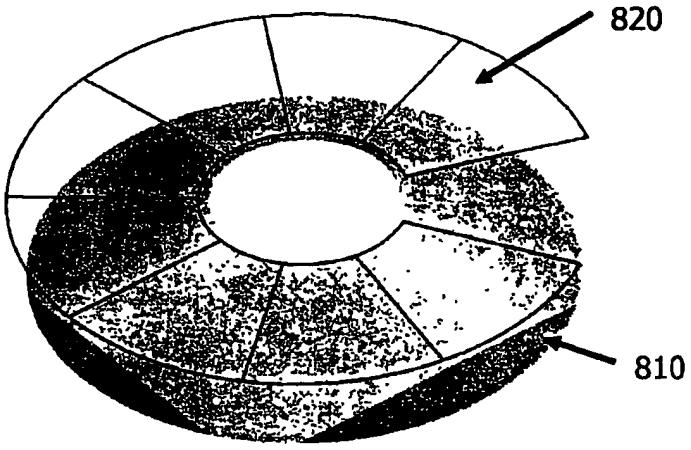


Figure 9

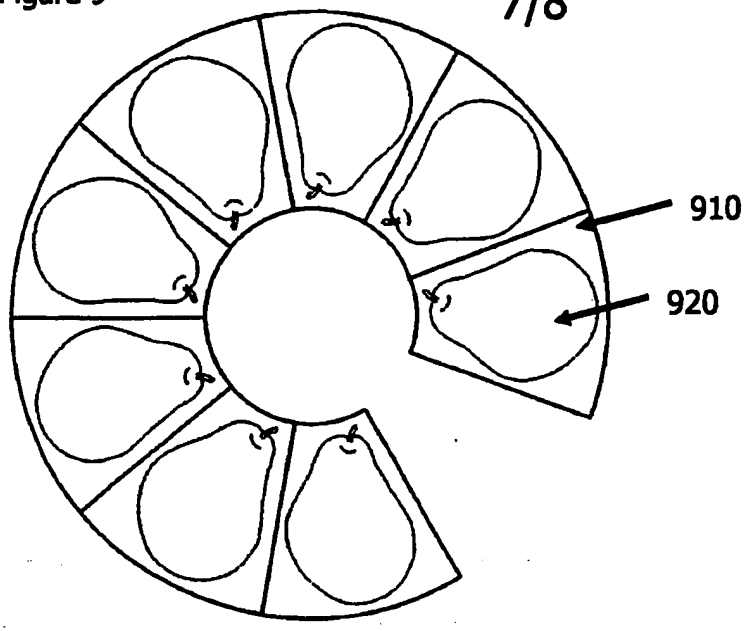


Figure 10

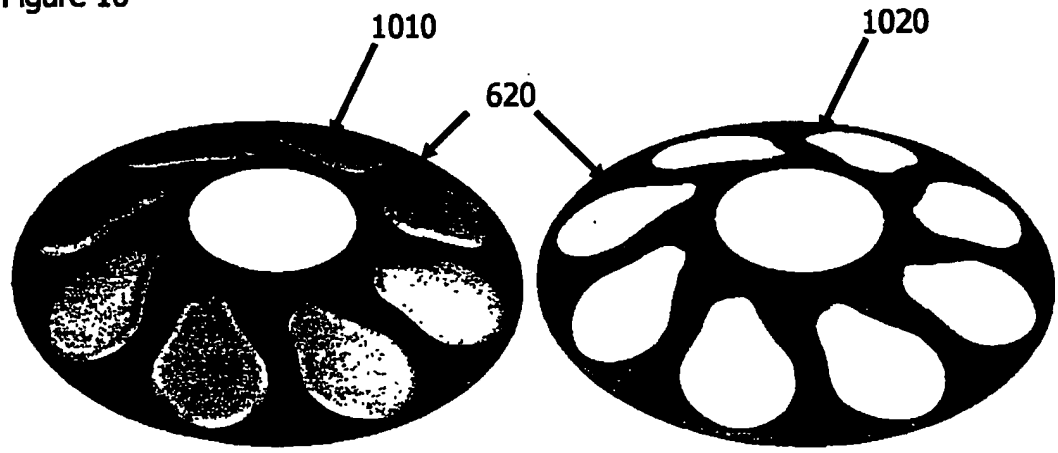


Figure 11

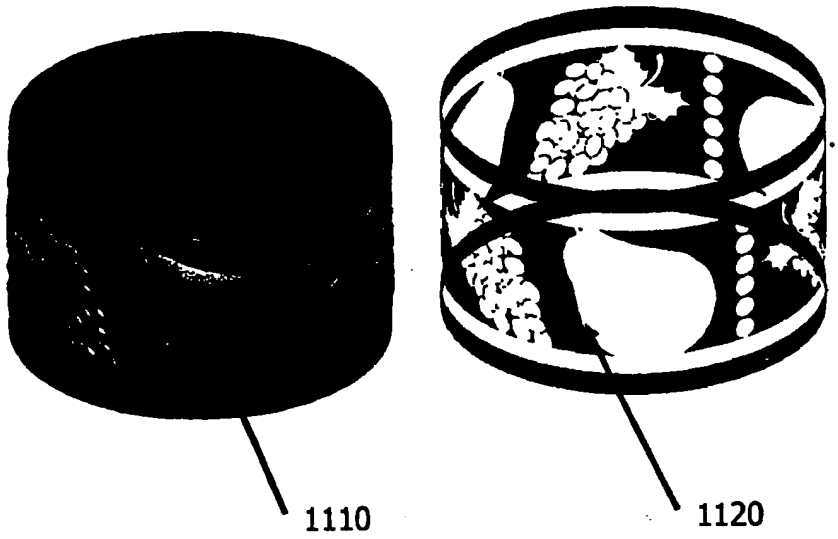
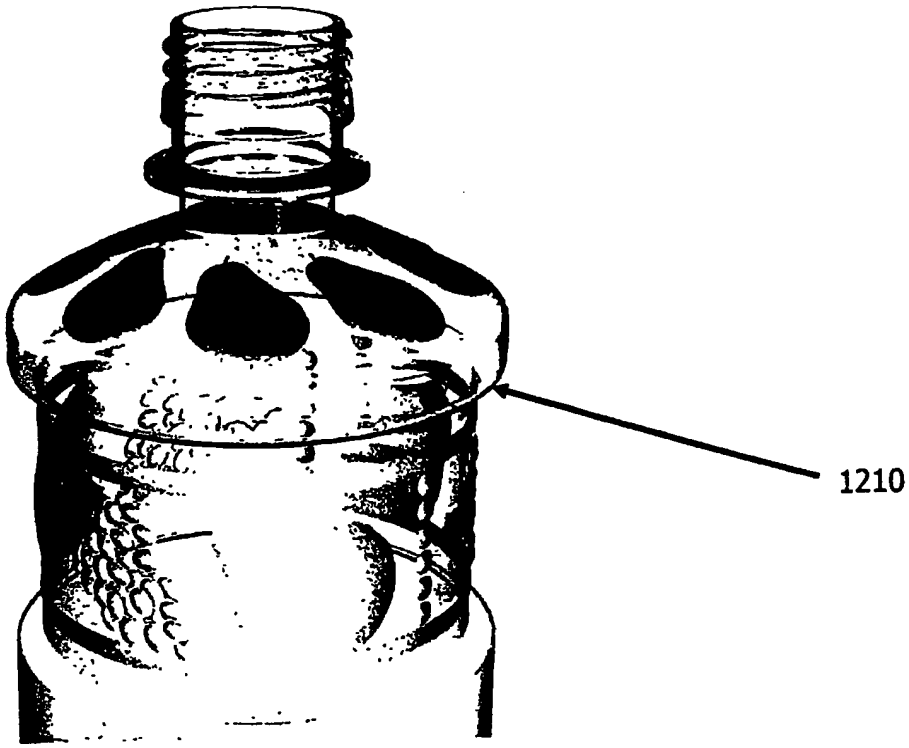


Figure 12



WRAPPING COMPLEX TEXTURES ONTO 3D CAD MODELS

FIELD Of INVENTION

This invention relates to an advantageous method of wrapping complex textures onto the 3D CAD model of a product article, for example, a bottle or some other container, with a view to manufacturing a prototype of the product or the mould or die cavity and/or core to create the product.

BACKGROUND TO INVENTION

Textures may be either decorative or functional. Decorative textures are found on parts such as motor vehicle trim panels (car door interiors, dashboards etc.), bottles and containers, and consumer goods of all types. Functional textures are found on items such as power tools where they provide extra grip, or serve some other purpose.

It is known how to create such textures using a variety of techniques such as engraving, etching, appliqué etc. The existing methods are typically time consuming and labour intensive, and also inflexible in that they do not permit easy editing of the texture in the event of a design modification. Neither do they allow the relief to be inverted (converted from raised to depressed) for making a mould or other type of forming tool.

Previous published methods for achieving wrapping in a CAD environment, e.g. U.S. Pat. No. 6,673,281 issued to Yourist, have suffered from several important limitations. The CAD model for wrapping onto the target must be a triangulated representation of the surfaces and solids, rather than the original solid geometries themselves. Thus, subsequent edit operations have required considerable re-working. The target model geometric surface representation does not become trimmed, so is difficult to invert for moulding. Many separate files are needed to store the initial model and its wrapped representation, making data management complex. The low relief model used as the wrapper had to be created as contour maps with a tool such as Delcam plc's ArtCAM Pro™ software. Defining the original shape for a relief that had to fit an exact area of the target was complex and time consuming.

SUMMARY OF INVENTION

The present invention shown provides a means for wrapping complex 3D low relief models onto CAD models. The low relief texture used for wrapping can be created from any source that is capable of generating triangle data. The 3D relief model and the original 3D model may be shown together on a graphical display such that the operator may select the area on to which the relief should be wrapped. Areas of the original model that

would be obscured by the relief areas are trimmed (removed) such that inverting the model to define the cavity for moulding purposes is possible.

Methods are provided for minimising or eliminating any distortion effects caused by wrapping onto complex 3D forms. These methods include wrapping by cylindrical, conic, and planar projections, and wrapping according to local curvature of the target model.

Methods are provided for unwrapping selected regions of the target to provide a template for designing the low relief wrapper.

The wrapped relief becomes a feature of solid CAD model, and is automatically redefined if the target CAD model is changed as the result of a design modification. The resultant combined model may be displayed graphically a single seamless model. The model may be used to generated 2D slices for rapid prototyping manufacturing machines or to generate 3D tool paths to machine either side (male or female) of the combined model's surfaces.

The finished model, incorporating the initial mode and the relief is stored in a single data file.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 Shows the processing means

Figure 2 Shows an outline of the steps carried out in present invention.

Figure 3 Shows a flow chart of unwrapping selected areas of the target to use as a template for relief design.

Figure 4 Shows a flow chart of using one of the specialised unwrapping/wrapping methods (conical).

Figure 5 Shows an example target article being a plain bottle

Figure 6 Shows the same bottle with two regions isolated for wrapping (neck and body)

Figure 7 Shows the desired finished design

Figure 8 Shows the use of conical wrapping to extract the template for the neck region

Figure 9 Shows the outline of the finished relief ready for wrapping

Figure 10 Shows the relief in position, and the trimmed underlying surfaces.

Figure 11 Shows wrapping around 360 of a body, in this case using cylindrical wrapping

Figure 12 Shows a close up of the finished designs

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

According to the present invention a computer system (Figure 1) is used to process information using step outlined in Figure 2 to achieve the physical effect.

In Figure 2 the user creates the desired boundary model of the target part, for instance a container, using for example a parametric surface geometry representation (210). This may be accomplished using a combination of keyboard (106) and pointing device (108) to provide commands to the computer processor, which will be executing a CAD package, such as for instance PowerSHAPE™ from Delcam plc. The user will receive feedback on the progress of this creative process via the graphics display (102) depicting an image of the part being created.

The user must acquire the 3D low relief model from a graphical data input device such as a 3D scanner (110) or from the output of suitable engraving software such as ArtCAM Pro™ from Delcam plc (220). The 3D connected triangular mesh may be fitted to the 3D relief data points and is temporarily stored in the computer memory (112) pending the next operation.

The user will then position, orientate and scale the 3D relief geometry with respect to the target model (230) by controlling the CAD software executing on the computer processor. Once positioned, the nodes of the relief mesh are projected on to the target surface using the selected wrapping method, for example chord length, cylindrical or planar mapping. These projected nodes are offset by an appropriate distance from the target surface to represent the relief height. The nodes are then joined to create a wrapped triangular mesh surface model of the relief wrapped on to the target.

The next step is to find the boundaries of the triangulated relief surface where it meets the target surface (240). This allows trim curves to be created to trim back the surface of the target part so that there is no overlap between the relief surface and the target surface. The topological information relating to this edge curve to the surface is stored in the computer memory so that it can be recreated if there is any detailed change in the target surface geometry.

It should be noted that this method allows the stored model to be watertight such that accurate photorealistic renderings can be computed and displayed and significantly male and female representations of the form (for example a prototype and a mould cavity) can be manufactured by processing the stored computer model into instructions for either rapid prototyping or milling machines.

As an important enhancement to the method shown in Figure 2 the user can use the computer processor to unwrap the geometry of the target part (Figure 3) by using an appropriate method to create a planar unwrapping as a profile (320) that may be passed to a CAD system (330) or to a relief engraving system such as ArtCAM Pro™ from Delcam plc or another method for designing a low relief model. The advantage of this is that the relief can be designed using the knowledge of the space within which the relief should lie. The design relief should be converted to a triangulated model and then wrapped onto the target (370) (equivalent to 230 in Figure 2).

Figure 4 shows the process described in Figure 3 for the case of a conical unwrapping method chosen for the shoulder area of the container.

Figures 5-12 show a specific example illustrating the efficacy of the method for a 360 degree wrapping of relief. 710 is the desired design. Firstly, the 3D model of the container (510) is created or imported (310). The cylindrical region (610) is selected and unwrapped (320). The conical area shoulder area is selected and approximated by a primitive cone (420, 810). The cone unwrapping method is used to flatten the cone into 2D (430, 820). The flattened profile is used in a low relief modelling tool such as ArtCAM Pro to generate the low relief pattern, in this case a set of pear motif reliefs (450, 920). The low relief model is converted to a triangle model (460) and wrapped (470,1010) onto the original conical surface (620). The boundaries of the triangulated relief surfaces is used to create trim curves on the original conical surface (240, 1020).

The original cylindrical surface (610) is unwrapped (320) and the flattened flattened profile is used in a low relief modelling tool such as ArtCAM Pro to generate the low relief pattern, in this case a set of pear and grape motif reliefs (350, 1110). The low relief model is converted to a triangle model (370) and wrapped (380) onto the original cylindrical surface (610). The boundaries of the triangulated relief surfaces is used to create trim curves on the original conical surface (240, 1120).

The consolidated CAD model of the textured part is now suitable for design and manufacturing processes to produce for example graphical renderings (1210), physical prototypes, mould & die cavities to make this part.

CLAIMS

1 – A general method for wrapping 3D relief geometry onto a target complex 3D CAD model of a part.

2 – A general method for wrapping 3D relief geometry onto a target complex 3D CAD model of a part where relief geometry items are created as features of the underlying target CAD solid model and are rewrapped automatically in the event of design changes to target CAD model.

3 – A general method for wrapping 3D relief geometry onto a target complex 3D CAD model of a part where relief and target geometry are stored in a single database.

4 –Unwrapping the relevant portion of the complex 3D CAD model of the target and using this unwrapped geometry as an accurate template for creating the initial 3D relief texture prior to wrapping the relief onto the target complex 3D CAD model of the part.

Application No: GB0507256.6 **Examiner:** Steven Gross

Claims searched: 1-4 **Date of search:** 16 June 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4	GB2389764 A (DELCAM) See whole document
X	1 at least	US6673281 B1 (YOURIST) See whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC[07]

G06F; G06T

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI, INTERNET